

Pricing illiquid bonds

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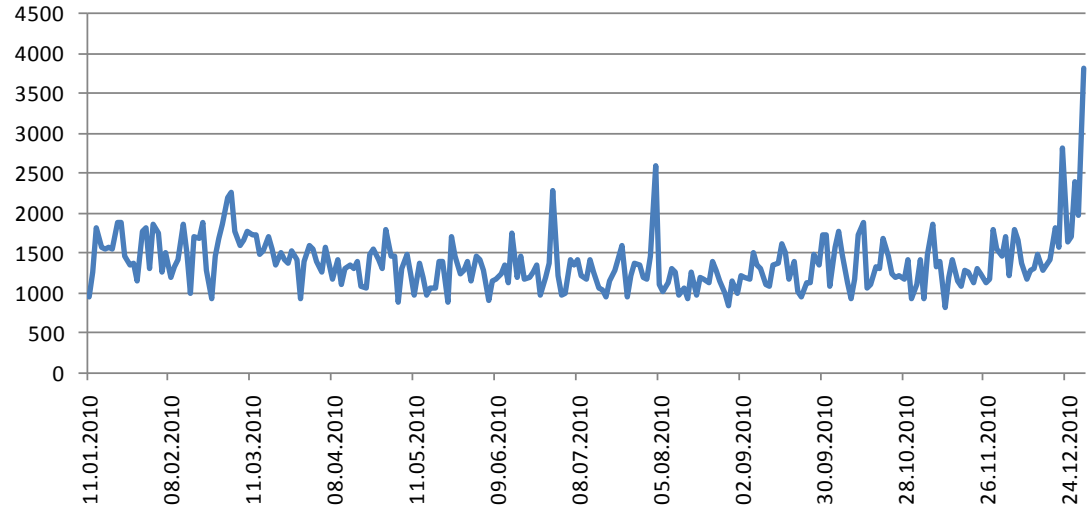
Head of division at Prognoz,

Associate professor at PSU,

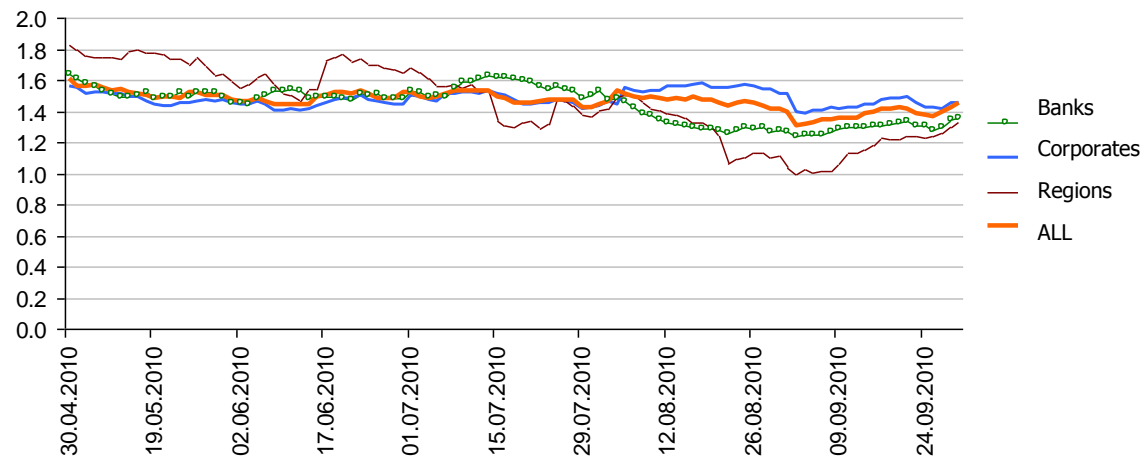
Head of Perm Risk Lab

Why is this an issue?

1378 deals per day on average...

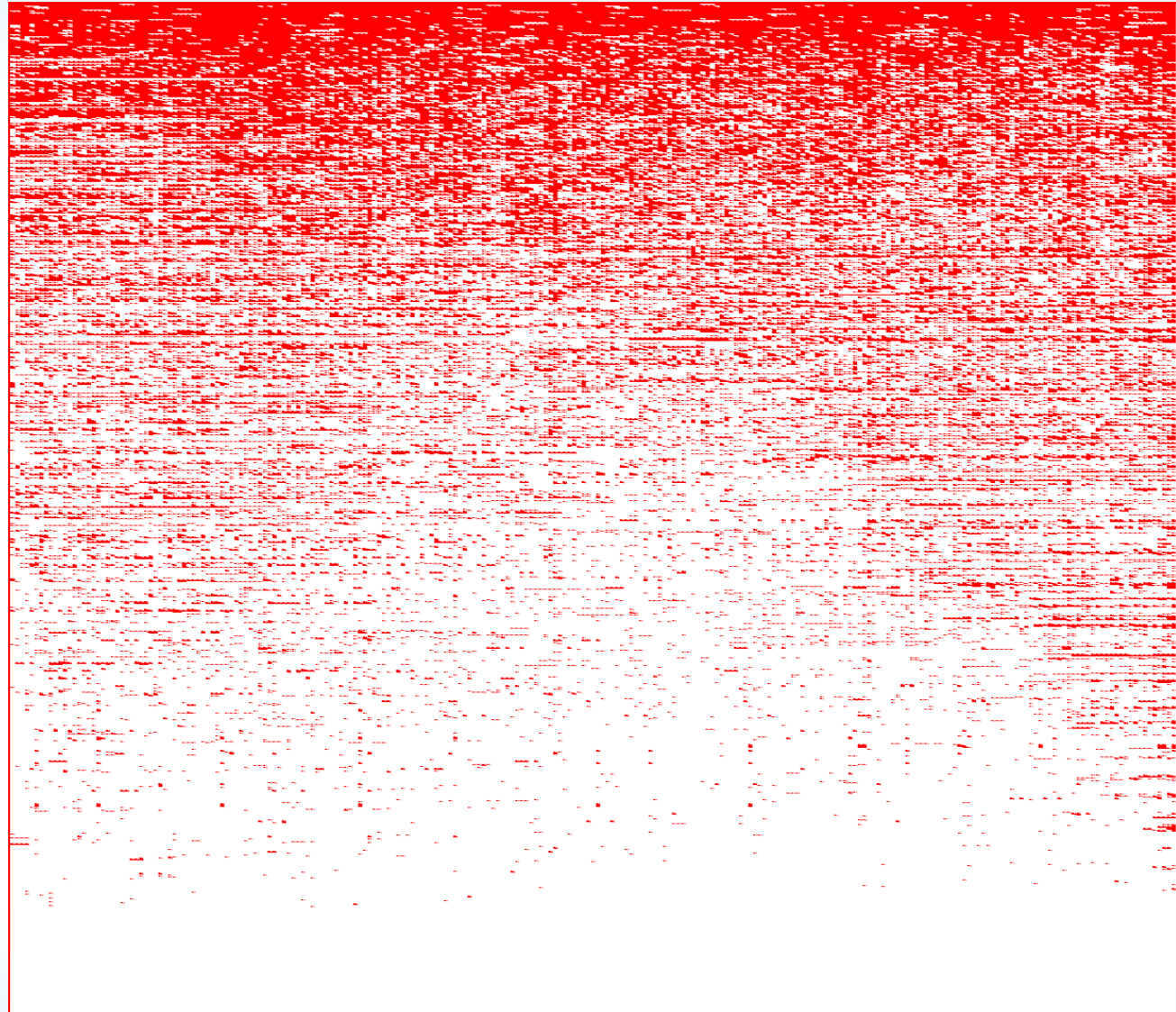


1,5 deals per bond on average daily...

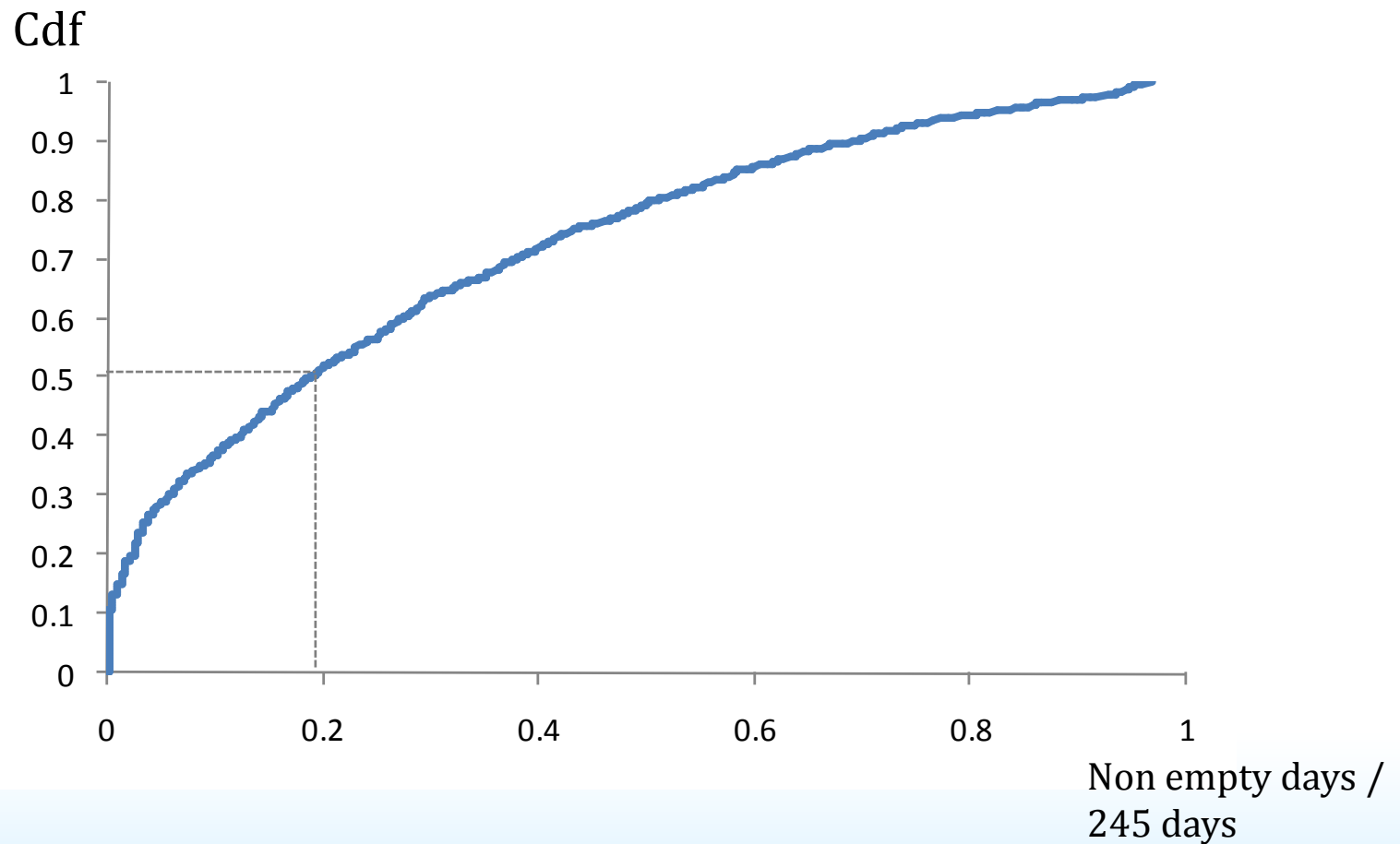


Market Map

925 bonds
245 days



Data sufficiency



Why do we need fair pricing?

1. Accounting

Financial Accounting Standards No. 157: Fair Value Measurements ("FAS 157") - 3 levels:

- based on quoted price

- based on market observables: quoted prices for similar assets, yield curve, credit spreads

- unobservable

2. Risk management

3. REPO market

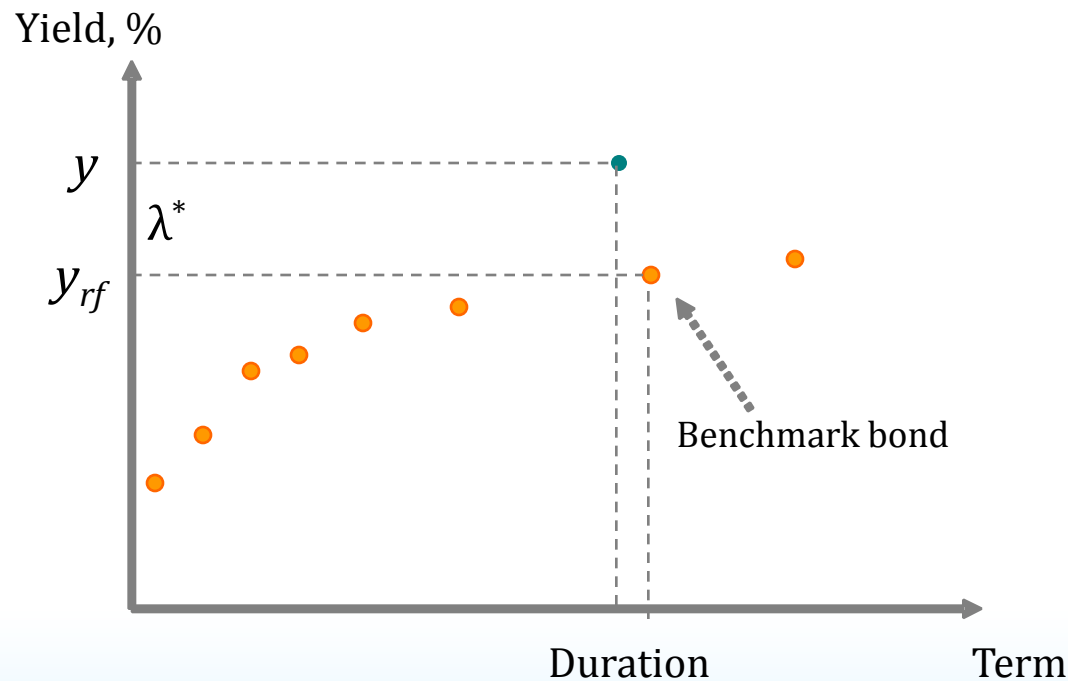
4. Taxation, etc.

Common practice of pricing...

$$\hat{P} = \sum_{i=1}^N F_i \underbrace{(1 + y)^{-t_i}}_{y_{rf} + \lambda^*}$$

y_{rf} - YTM of benchmark bond

λ^* - spread to benchmark



Benchmark pricing is simple, but...

- 1) Which benchmark to select?
- 2) What about different conventions?
- 3) What about term structure?
- 4) Is it good enough for precise pricing and risk management?

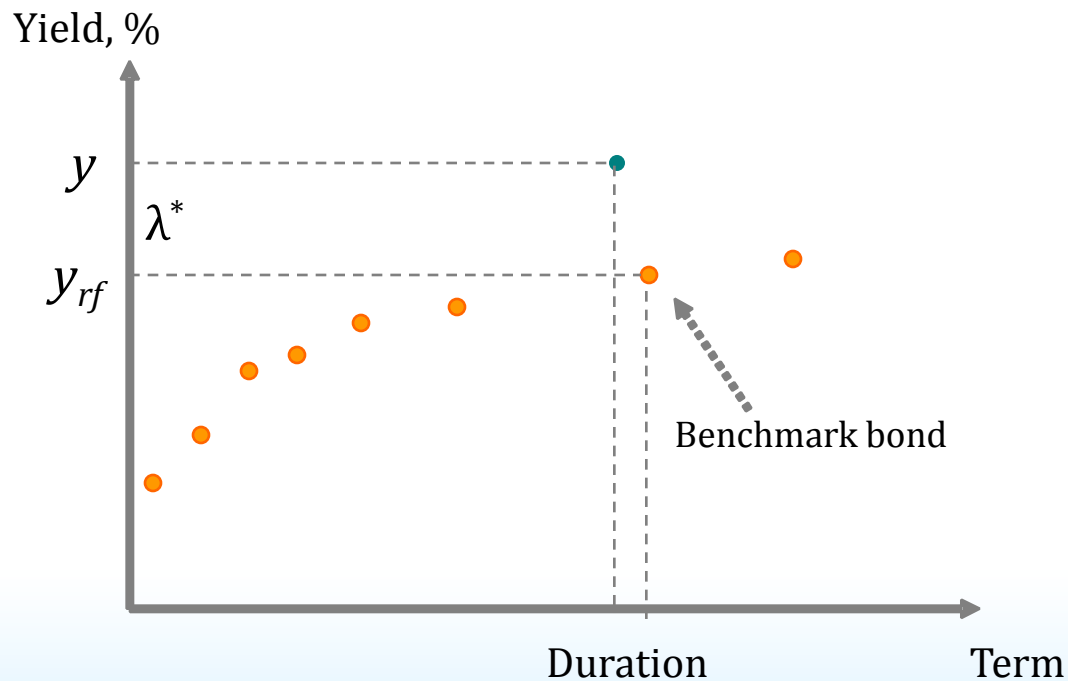
Better way of pricing should be...

Independent to benchmark selection

Independent to conventions

Dependent to term structure

} More precise

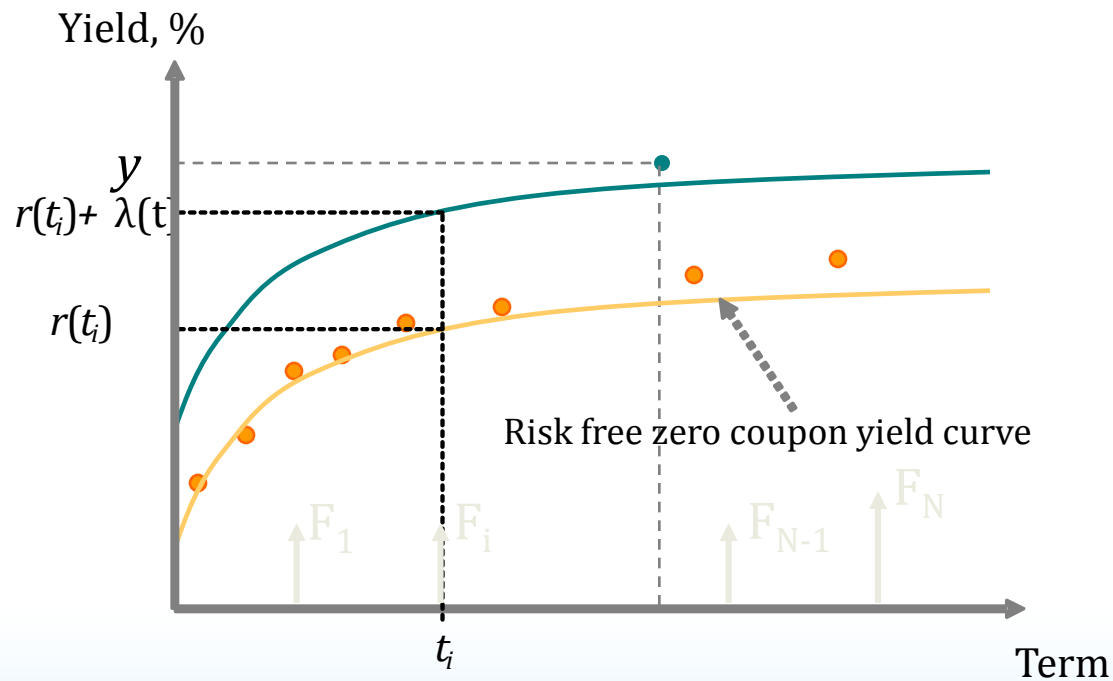


...and it is zero coupon pricing

$$\hat{P} = \sum_{i=1}^N F_i e^{-(r(t_i) + \lambda(t_i))t_i}$$

$r(t)$ – risk free zero coupon curve

$\lambda(t)$ – credit spread curve,
usually $\lambda(t) = \lambda$ (z-spread)



Risk can be decomposed...

$$\hat{P} = \sum_{i=1}^N F_i e^{-(r(t_i) + \lambda)t_i}$$

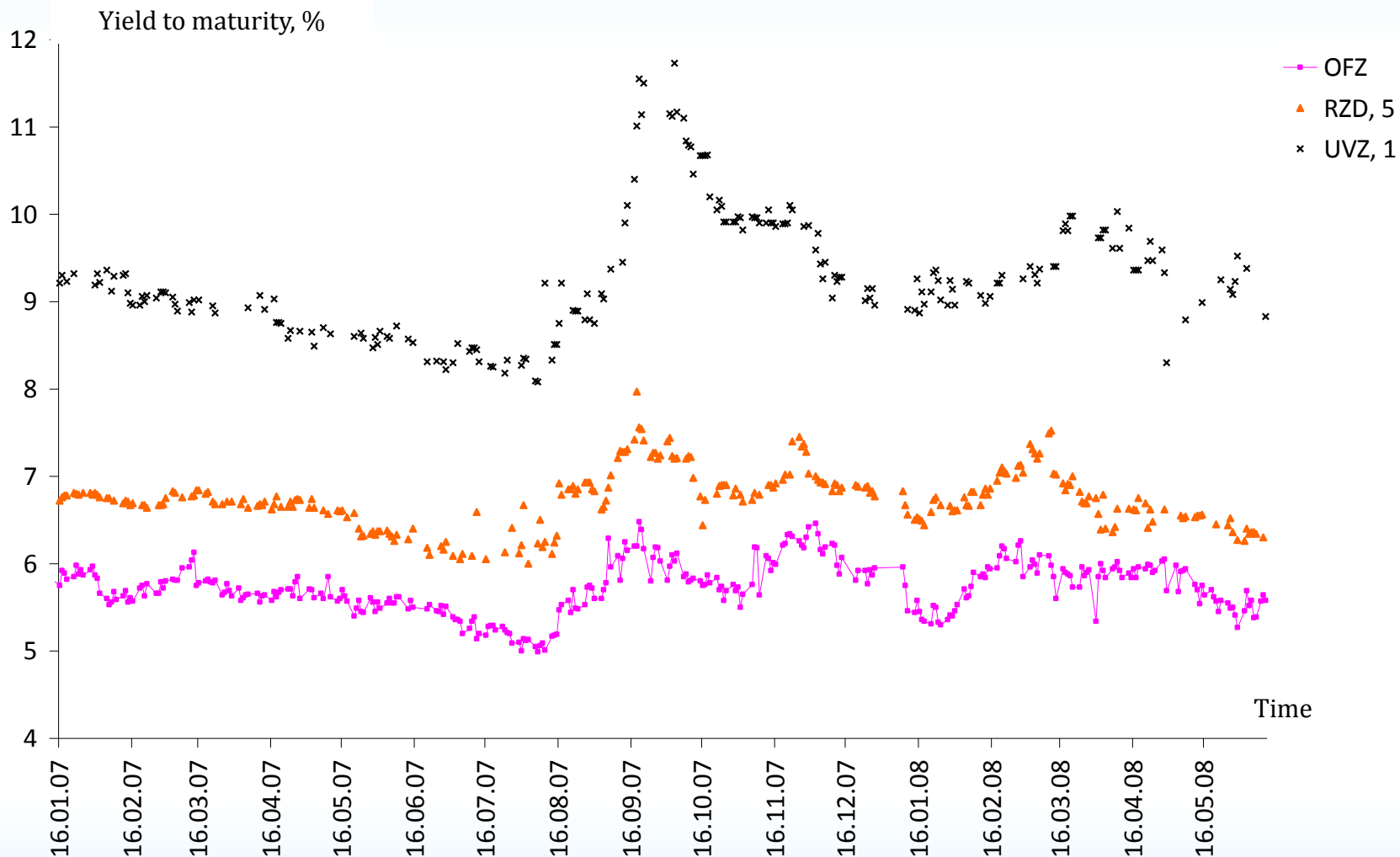
Bond market risk =

General risk: risk-free zero coupon yield curve
volatility

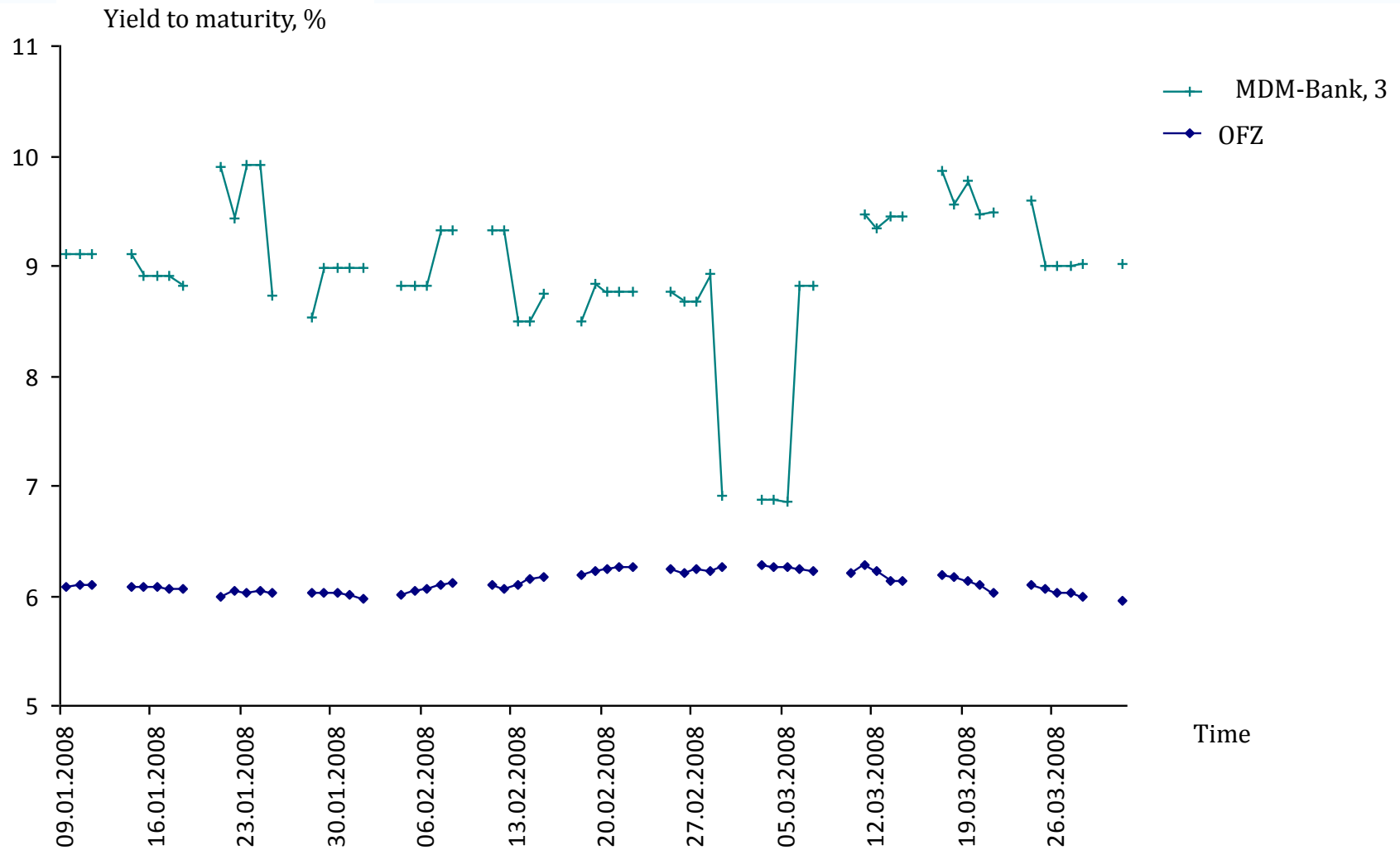
+

Specific risk: credit spread volatility

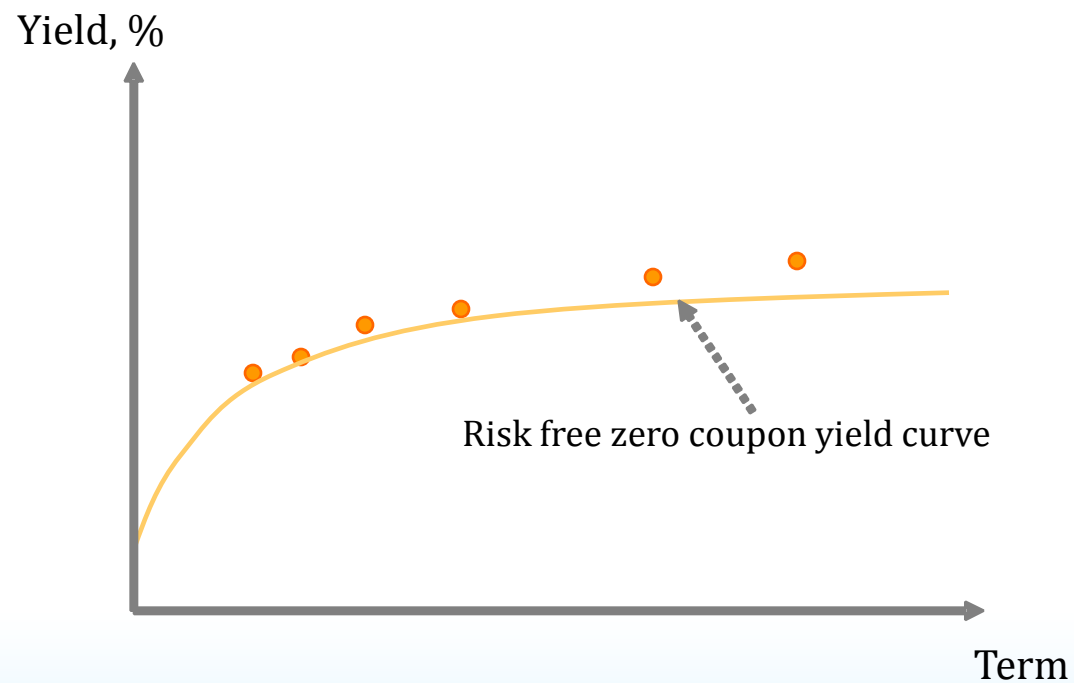
Usually general risk dominates...



...but sometimes it's more to specific

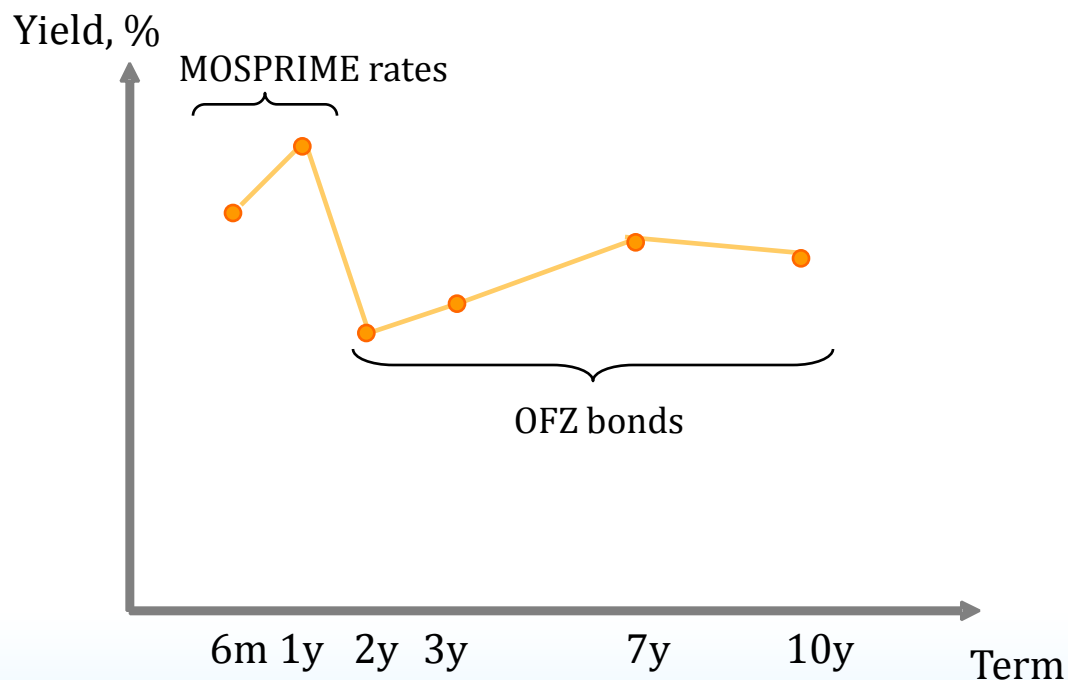


How to get the correct zero coupon yield curve?



Benchmark curves are not so good...

For example, RUR zero coupon yield curve from Bloomberg is constructed piece wise linear from MOSPRIME rates in the short term (<1y) and yields of OFZ bonds in the long term

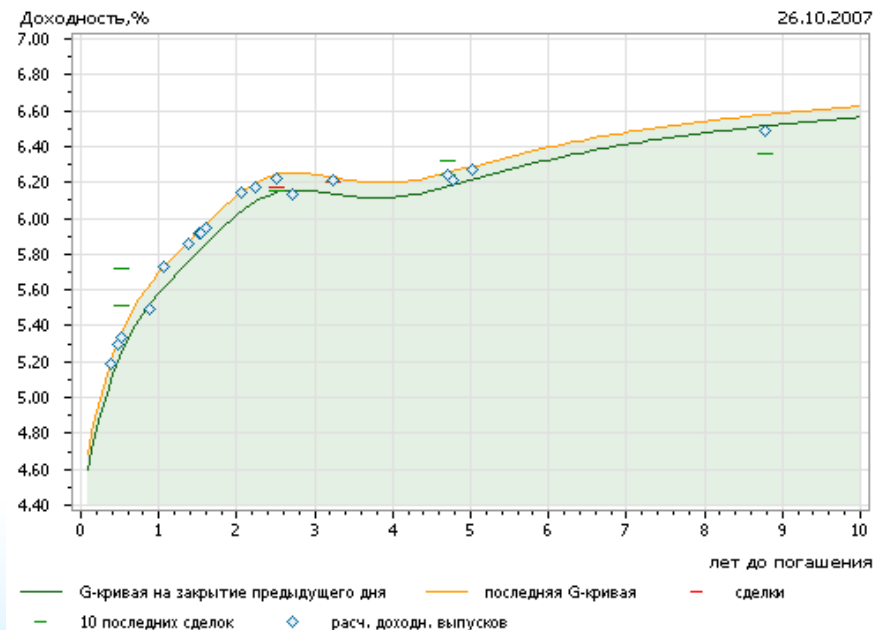


Another benchmark curve for RUR zone, MICEX G-Curve also has problems:

- Humps on the 1Y-3Y piece due to parameterization formula
- Critical dependence on the ordering of simultaneous deals
- Inconsistent spot forward rates
- Arbitrage possibilities
- And so on...

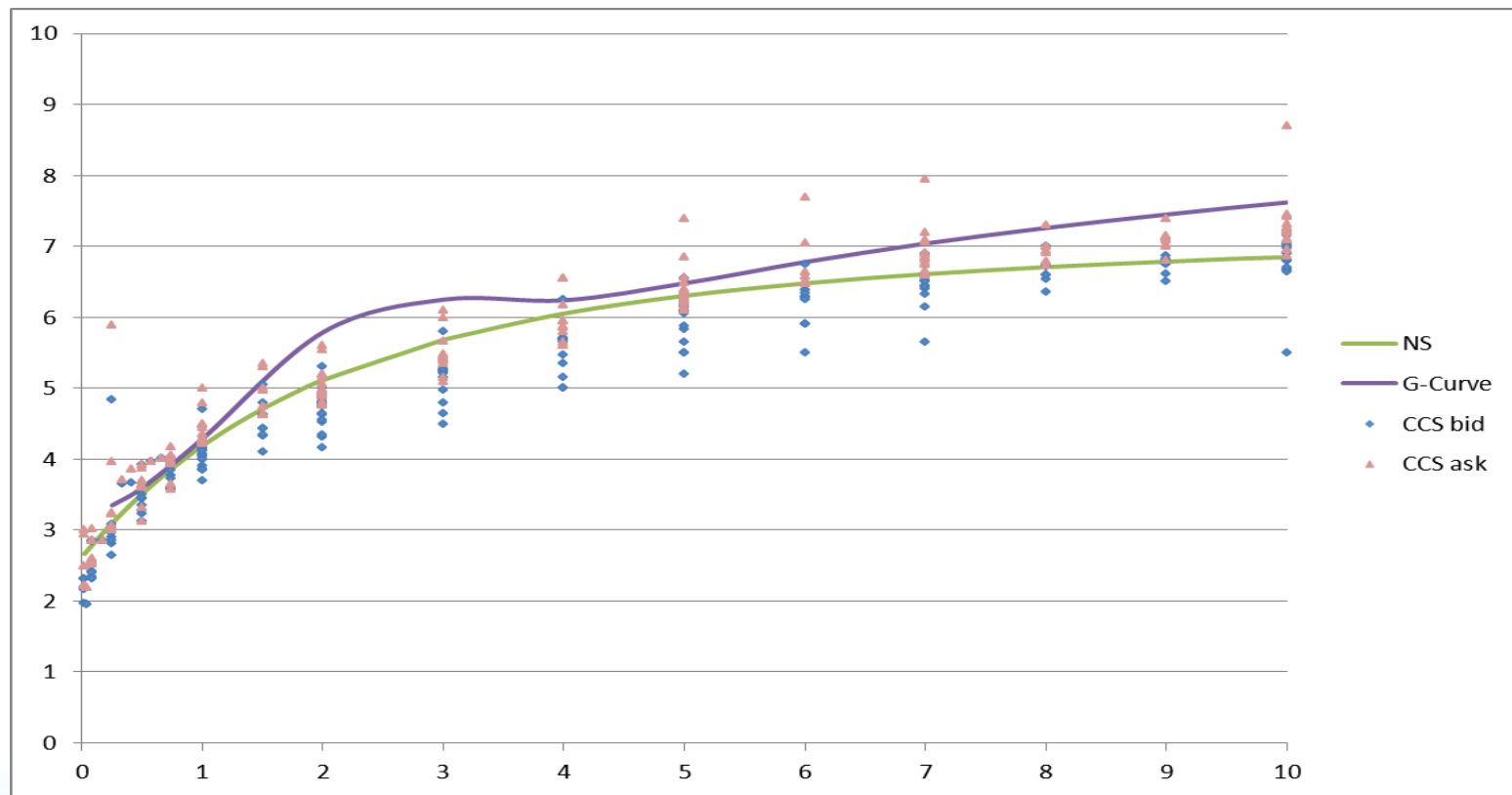
Detailed study:

<http://riskconference.ru/presentation/2008/Ivliev-Kosyanenko-Lapshin.pdf>



NDF/CCS curve is better...

We just need to take NDF / CCS quotes and fit the curve, for example, Nelson-Siegel...



BUT, it is not bond market...

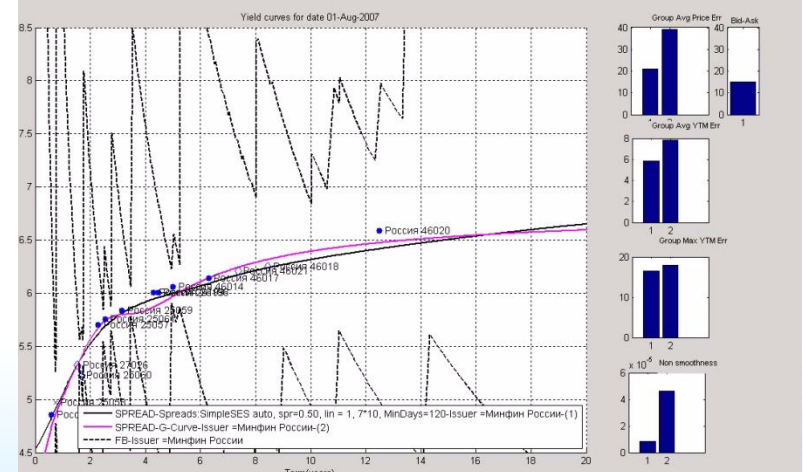
The “right” curve should be:

- Accurate enough
- Smooth enough
- Robust enough
- Consistent with market
- No arbitrage possibilities

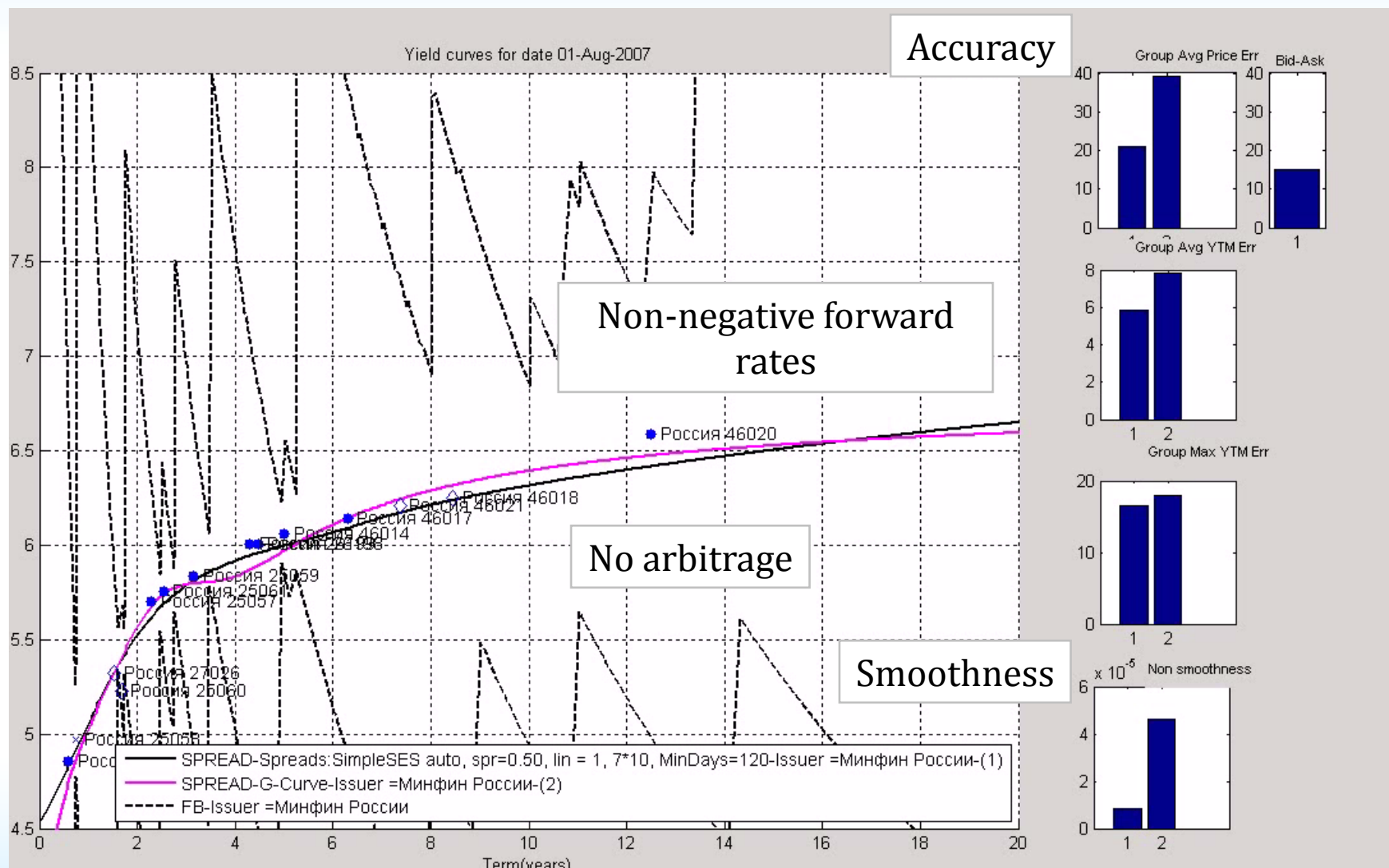
The answer is SES

Please refer to:

<http://riskconference.ru/presentation/2008/Ivliev-Kosyanenko-Lapshin.pdf>



What makes the difference?



Sinusoidal-Exponential Spline (SES) Curve...

SES method has been successfully used on such different markets as:

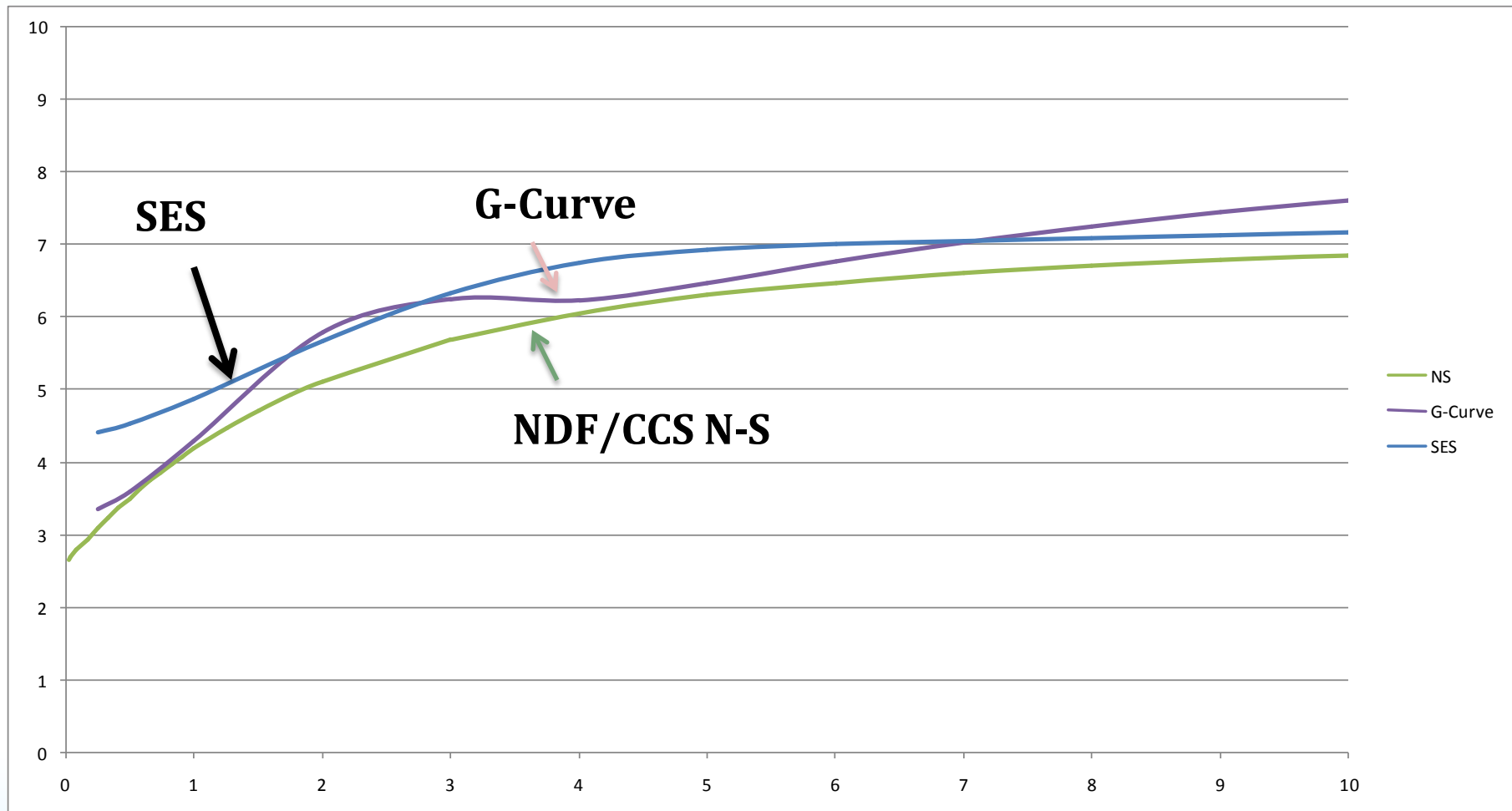
- Eurozone government bonds.
- Swiss municipal bonds
- Russian government and corporate bonds
- China government bonds

Developed by FERM LAB. Approved by EFFAS-EBC.

Software product developed by Prognoz.

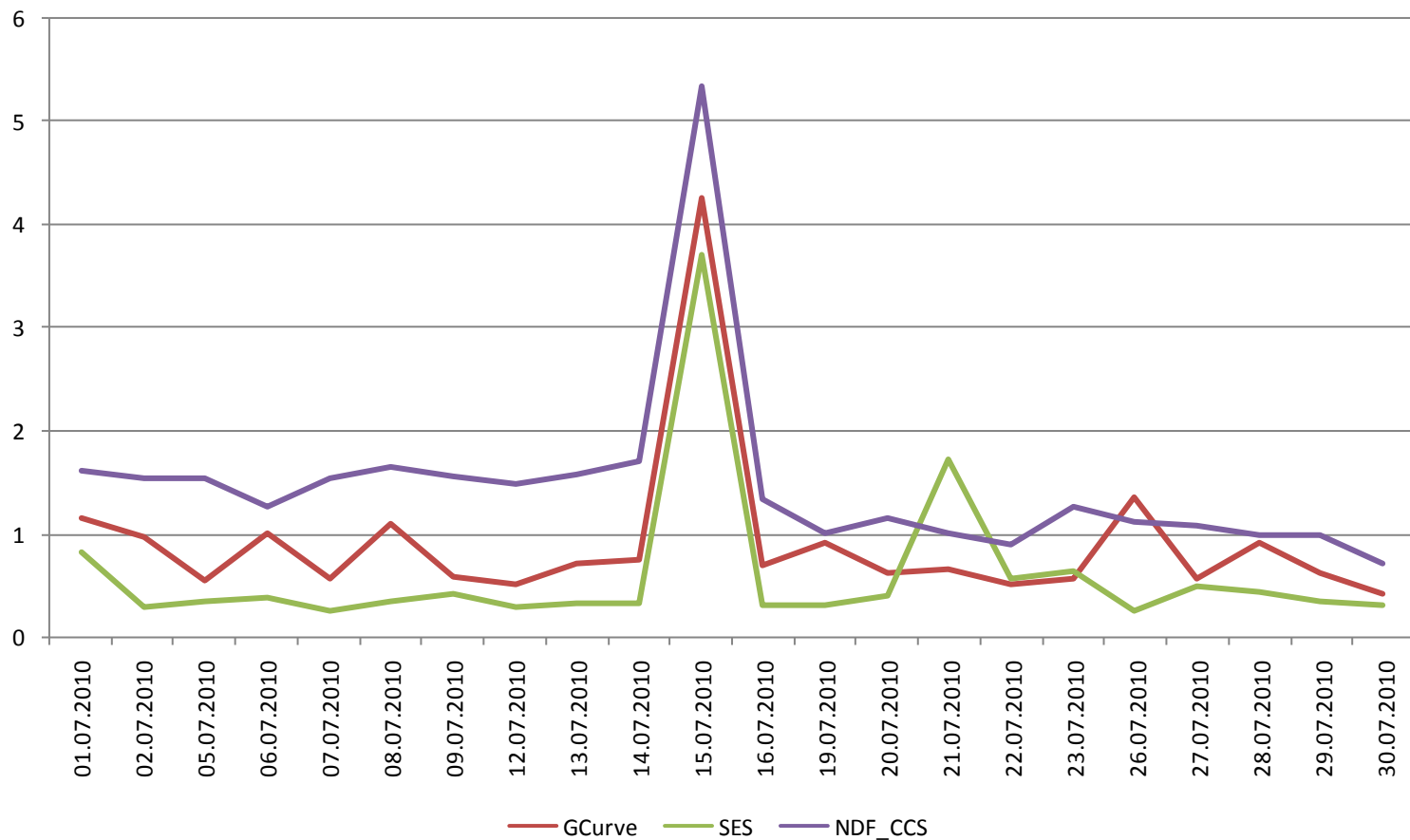
Implemented in Deposit insurance agency, Sberbank of Russia, Vnesheconombank, etc.

NDF/CCS N-S, SES, G-curves at 1/7/2010...



Which curve to select?

Monitoring the accuracy...



Credit spreads calibration: procedure

1. Get risk free zero coupon yield curve, $r(s)$
2. Shift risk free curve by spread λ
3. Calculate model price for each bond issued by entity:

$$\hat{P}(\lambda) = \sum_{i=1}^N S_i e^{-(r(t_i)+\lambda)t_i}$$

4. Calibrate λ to minimize residual sum of squares of model price versus market price

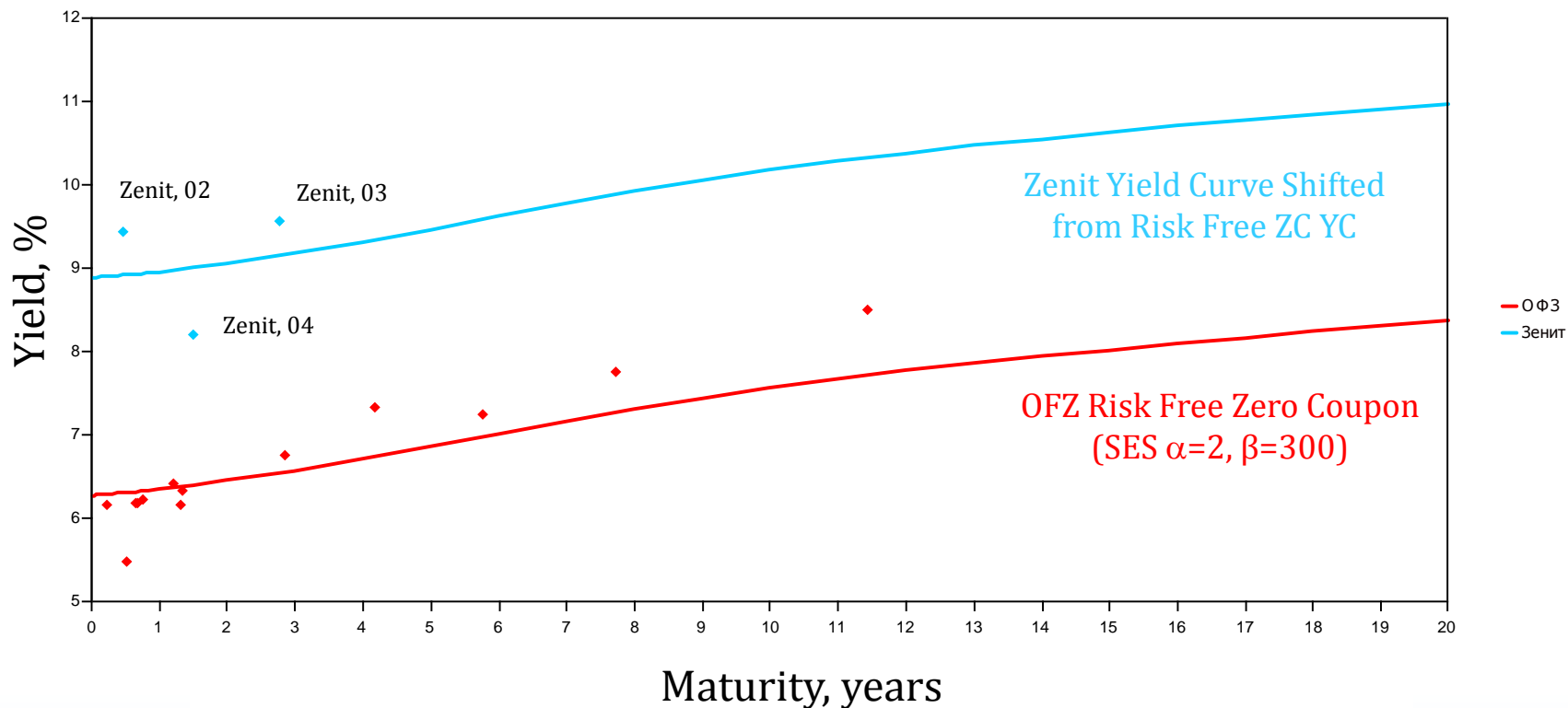
$$\sum_{k=1}^K (\hat{P}_k(\lambda) - P_k)^2 \xrightarrow{\lambda} \min$$

Special cases: put/call option, no coupon rates announced

Credit spread calibration: example

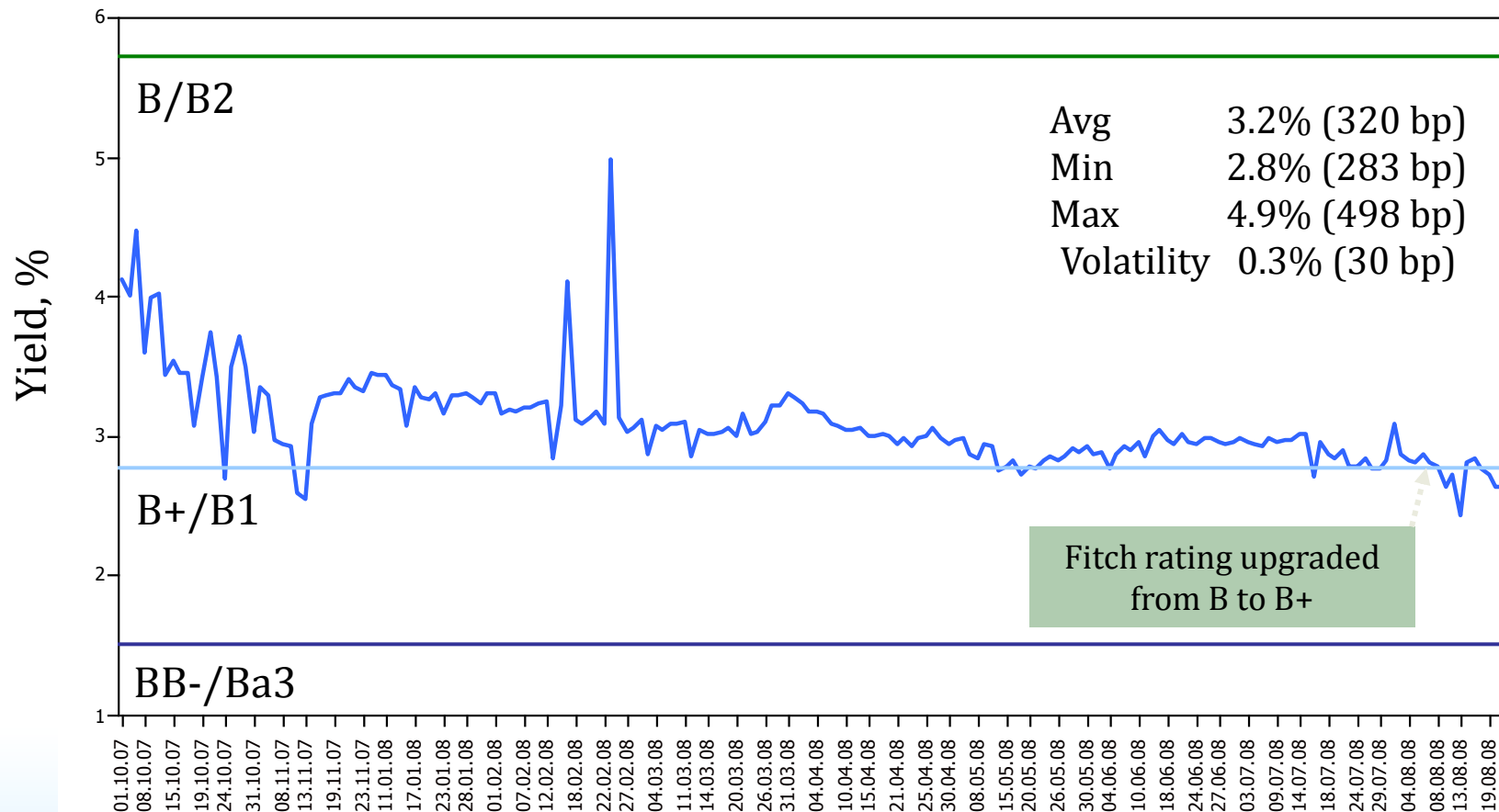
Credit spread calibration for Bank Zenit

$\lambda=2.61\%$



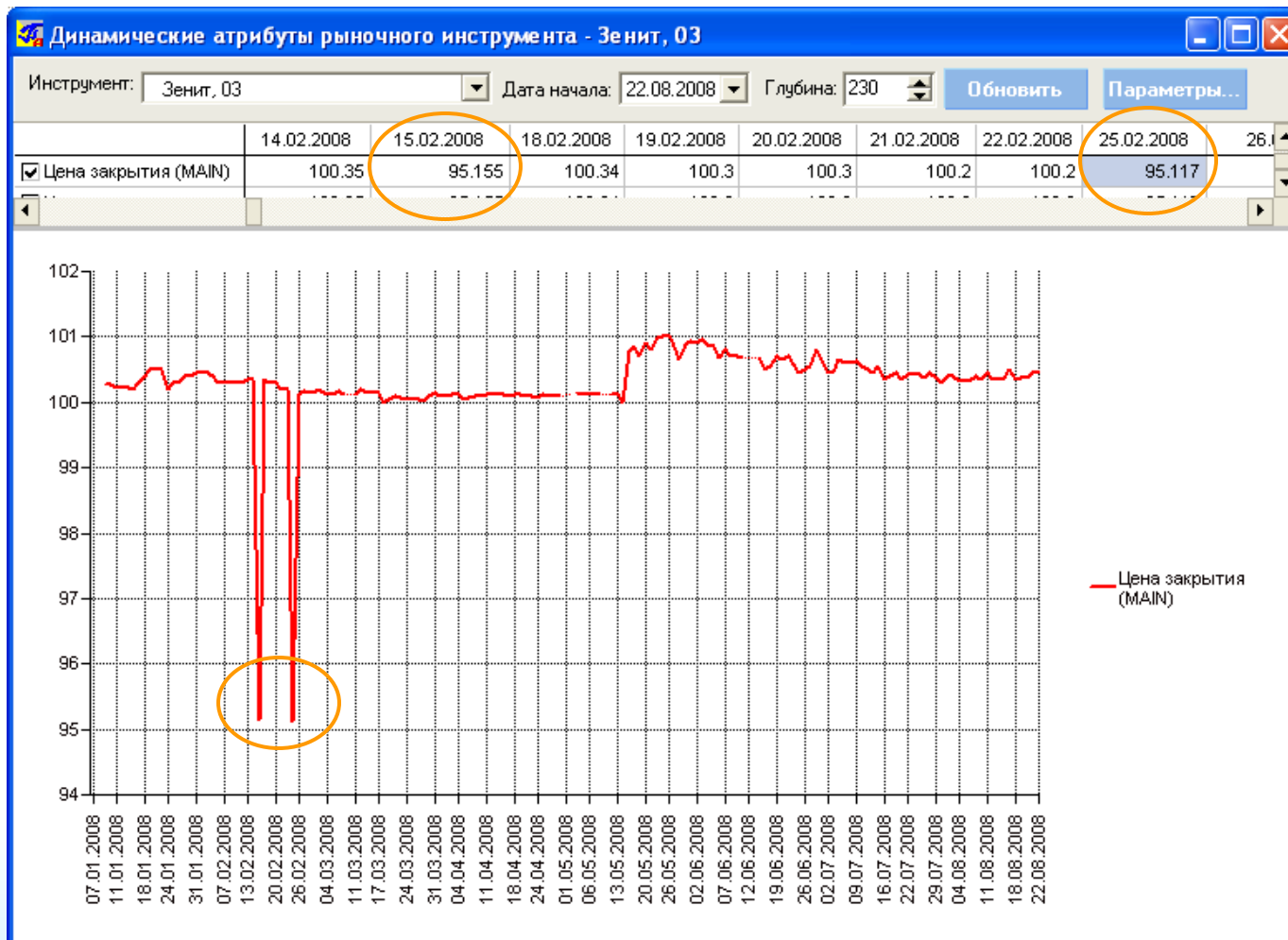
Credit spread time series

Credit spread for Bank Zenit (Moody's Ba3, Fitch B+ (from 5/08/2008))

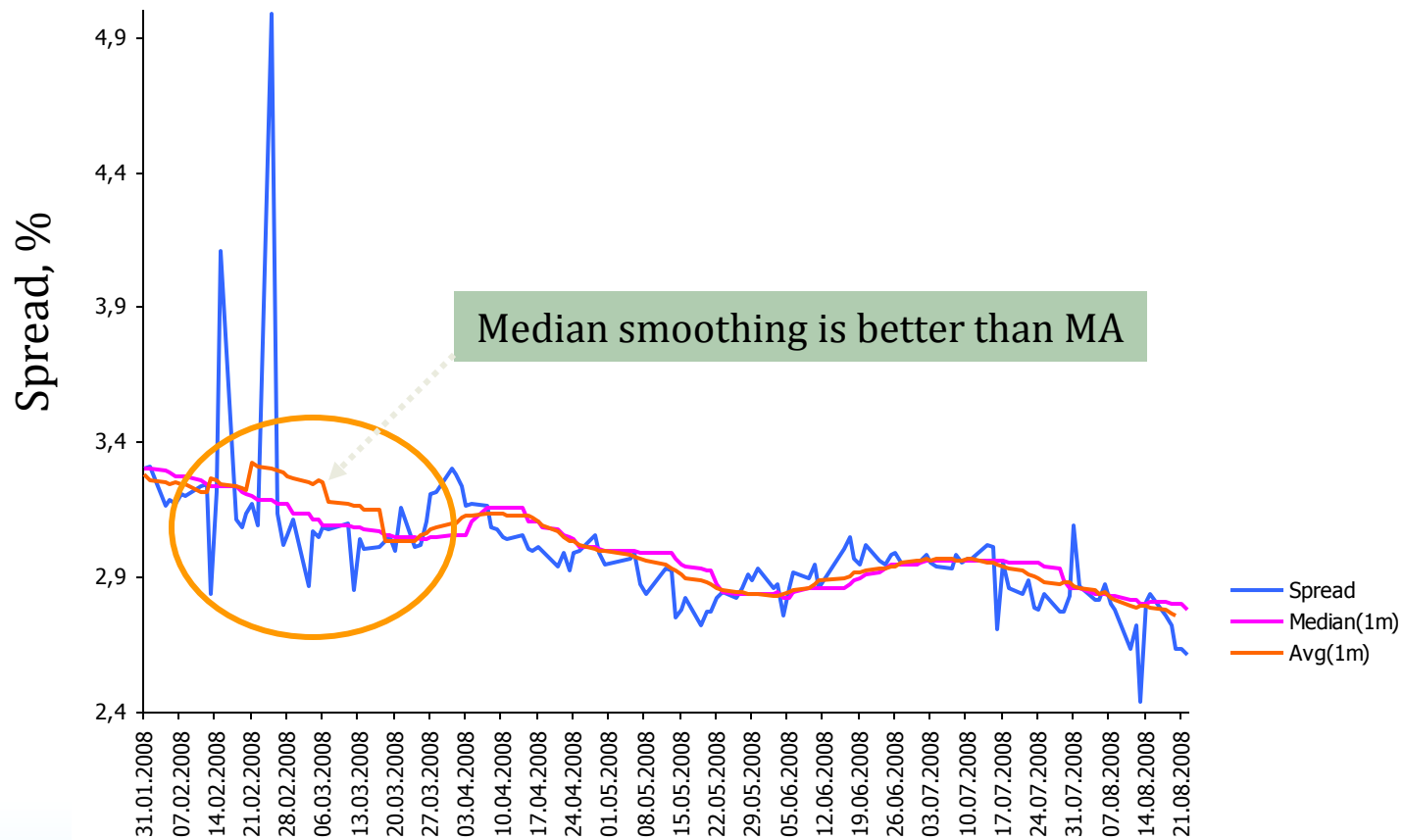


Outliers in the market price...

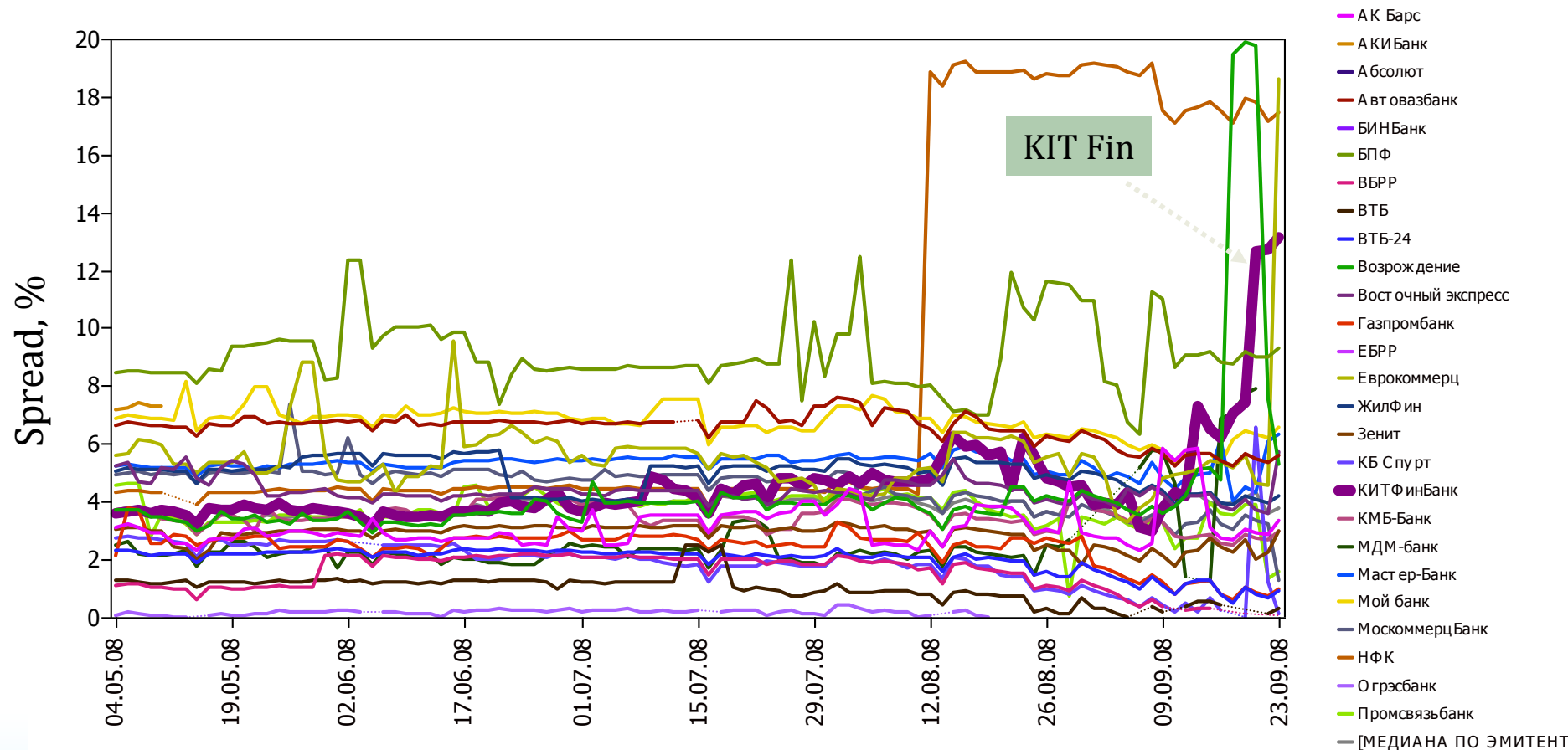
Close price for Zenit, 03



To eliminate outliers we can use smoothing...

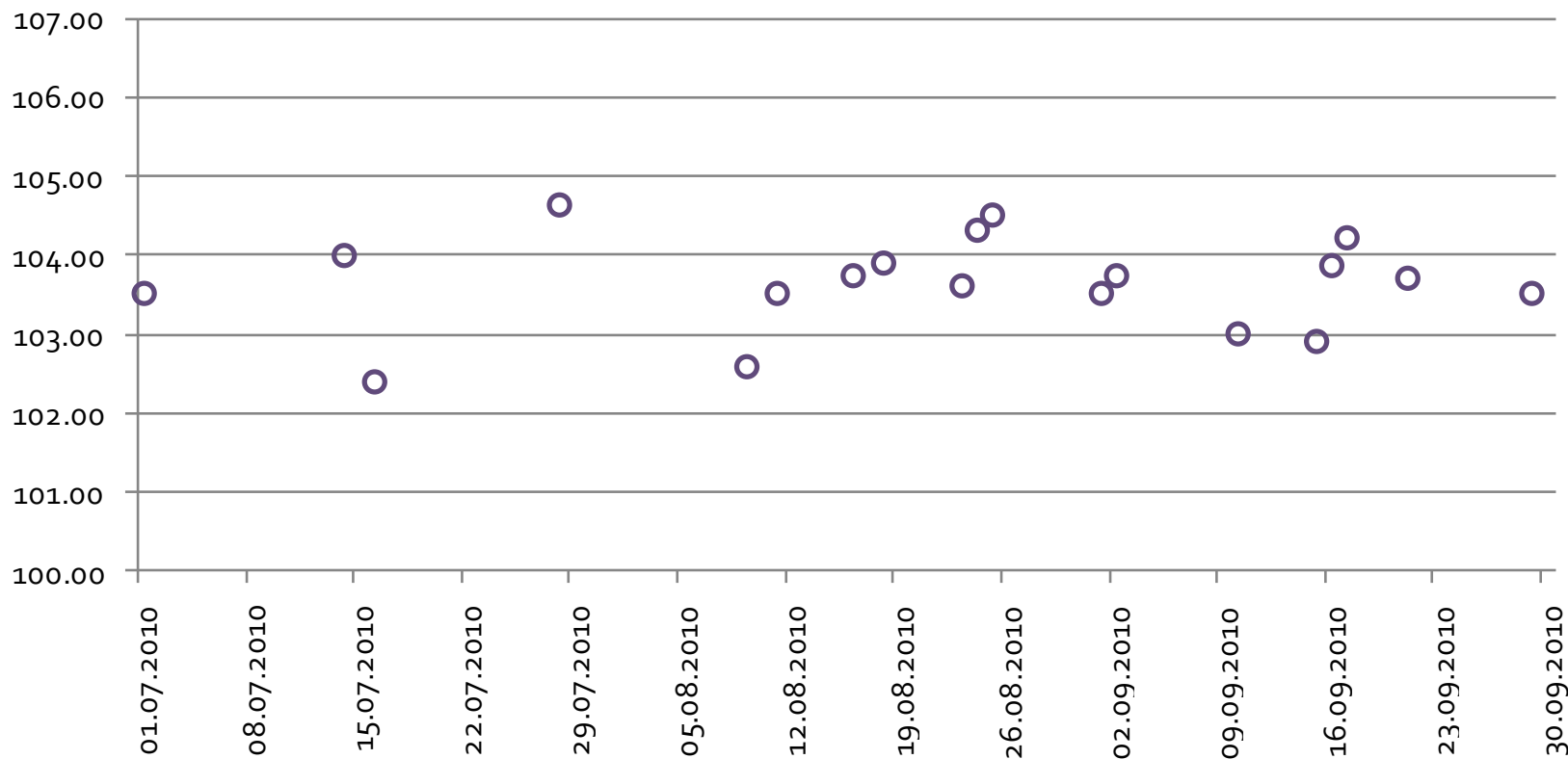


So we got credit spreads, what's next?



Illiquid bonds – a little bit of prices, a little bit of spreads...

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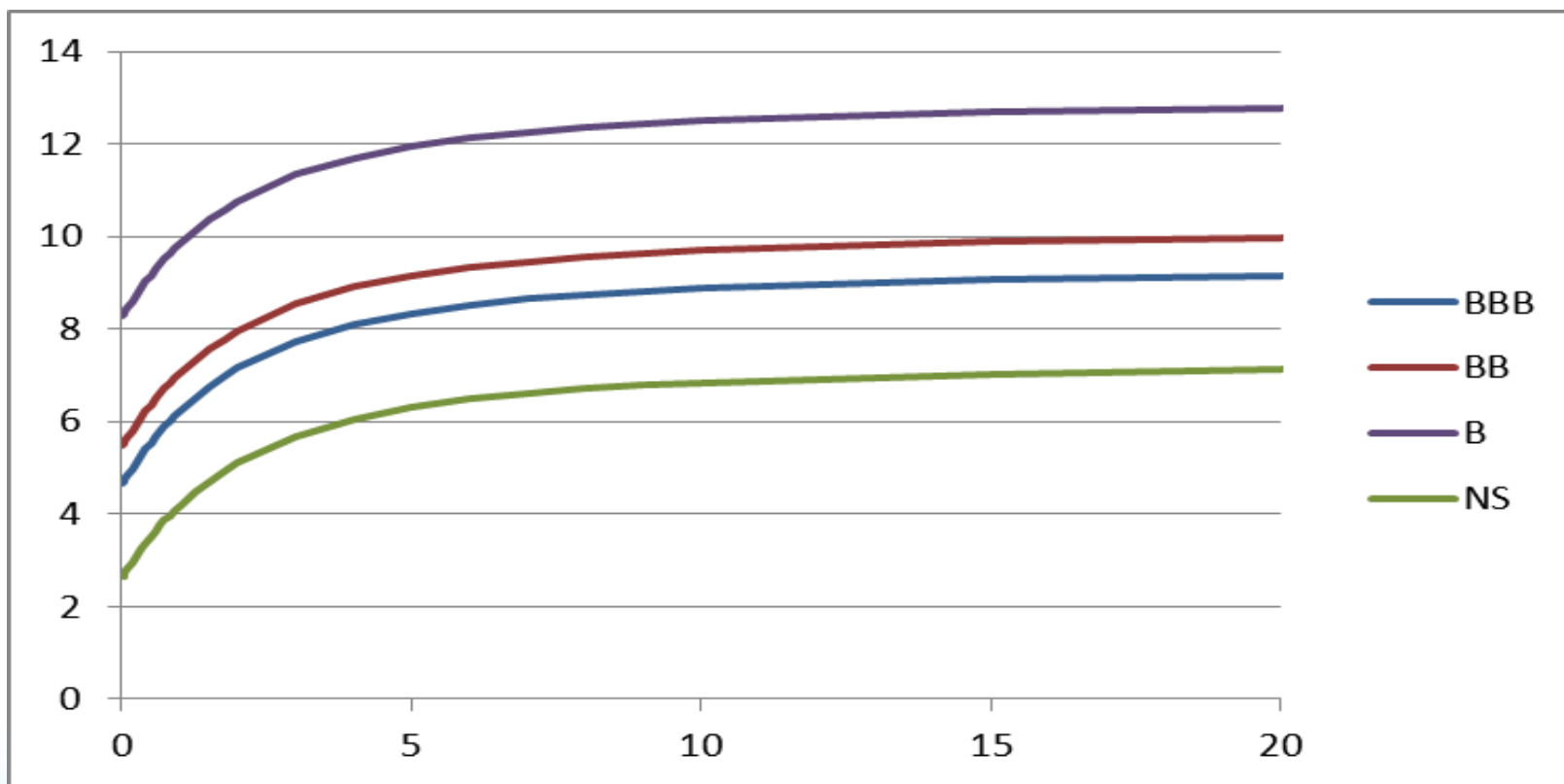


If there is no spread we should forecast it...

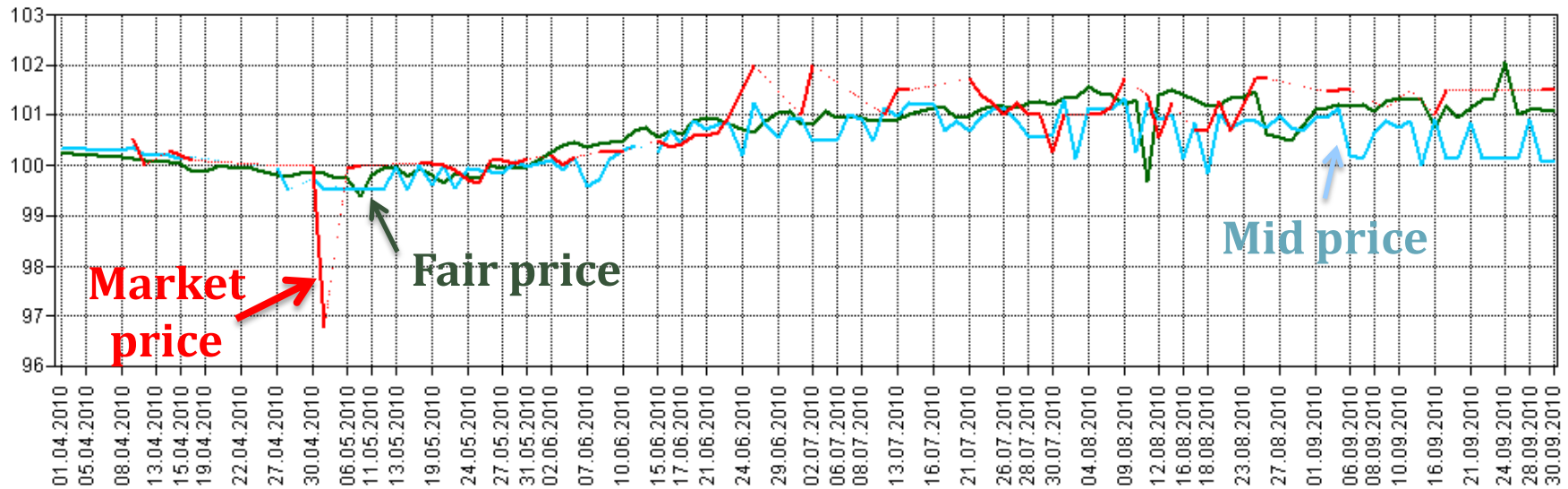
We can use credit rating

Эмитент	Присвоенный кредитный рейтинг
ОАО "АКЦИОНЕРНАЯ КОМПАНИЯ ПО ТРАНСПОРТУ НЕФТИ "ТРАНСНЕФТЬ"	BBB
ОАО "ГАЗПРОМ НЕФТЬ"	BBB
ОАО "НЕФТЯНАЯ КОМПАНИЯ "ЛУКОЙЛ"	BBB
ОАО "РОССИЙСКИЕ ЖЕЛЕЗНЫЕ ДОРОГИ"	BBB
ОАО "ФЕДЕРАЛЬНАЯ СЕТЕВАЯ КОМПАНИЯ ЕДИНОЙ ЭНЕРГЕТИЧЕСКОЙ СИСТЕМЫ"	BBB
ОАО "ГАЗПРОМ"	BBB
ОАО "ГОРНО-МЕТАЛЛУРГИЧЕСКАЯ КОМПАНИЯ "НОРИЛЬСКИЙ НИКЕЛЬ"	BBB
ОАО "МОСКОВСКАЯ ОБЪЕДИНЕННАЯ ЭЛЕКТРОСЕТЕВАЯ КОМПАНИЯ"	BB
ЗАО "ГРАЖДАНСКИЕ САМОЛЕТЫ СУХОГО"	BB
ОАО "Московская объединенная энергетическая компания"	BB
ОАО "ТАТТЕЛЕКОМ"	BB
ОАО "АКЦИОНЕРНАЯ ФИНАНСОВАЯ КОРПОРАЦИЯ "СИСТЕМА"	BB
ОАО "МОБИЛЬНЫЕ ТЕЛЕСИСТЕМЫ"	BB
...	...

Calibrate the credit rating curves...



...and use them to calculate fair price



Example: Ak Bars, 3

What if there is no credit rating? We should forecast it too.

It is like building IRB:

1. Calculate financial ratios:

Corporates - Debt/EBITDA, EBIT/Interest, ln(Assets), ...

Banks - ROE, ln(Assets), Cost/Income, ...

Regions - Debt /Budget Revenue, GRP YoY, ...

2. Calibrate IRB-model

3. Validate: ROC-curves, Accuracy Ratio, etc.

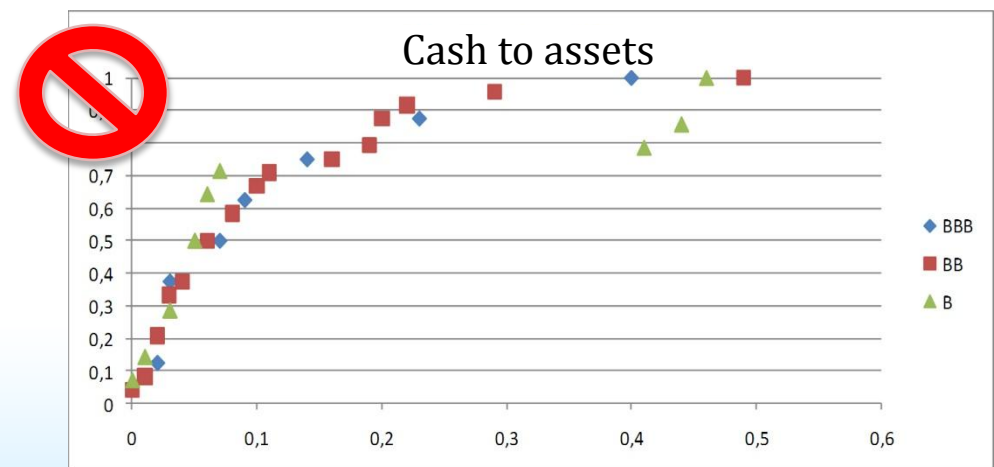
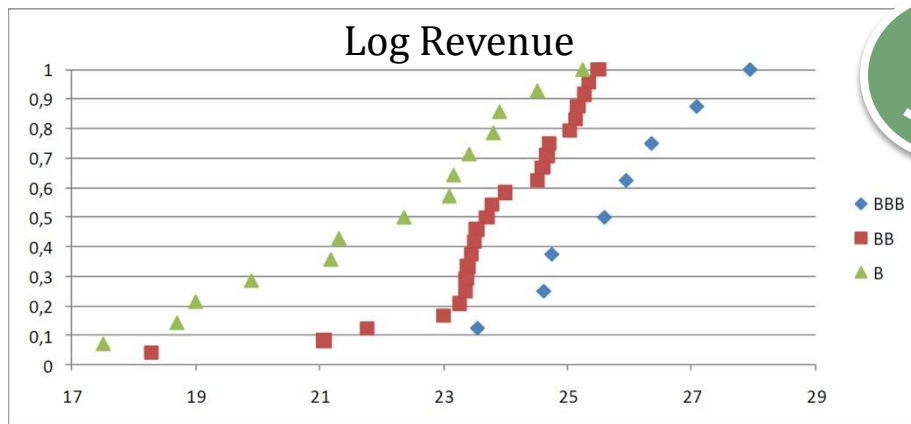
Simple algorithm

1. Calculate statistics for issuers that have credit ratings

Ratio	BBB	BB	B
Debt/EBIT	3.02	3.475	9.29
EBIT/Interest	8.98	5.035	0.37
LN(Assets)	27.38	25.12	24.24
Payables/Revenue	0.14	0.14	0.205
Retained Earnings/Short term debt	5.3	2.11	0.125
Equity/Assets	0.655	0.58	0.475
ROA	0.075	0.085	0.02
Operational Profit/Debt	1.03	0.43	0.15
Cash/Assets	0.08	0.06	0.05
Cost of debt	0.06	0.09	0.115
Ln(Revenue)	25.775	23.74	22.725
Retained Earnings/Assets	0.325	0.125	0.015
Current Assets/Assets	0.275	0.26	0.325
Operational Profit/Assets	0.13	0.11	0.06
Operational Profit/Short term debt	3.42	3.41	0.505
Revenue/Assets	0.38	0.565	0.365
Earnings/Cost of revenue	-0.41	-0.17	-0.02
EBT/Short term debt	2.485	2.36	0.095
EBT/Equity	0.18	0.15	0.05

Simple algorithm

2. Choose the best ratios for classification



Simple algorithm

3. For unrated issuer take the nearest cluster:

$$\rho(X_i, S_l) = \frac{1}{N} |rank(x_i) - rank(mX_l)|$$

or other metrics for e.g. Euclidian

Simple algorithm

4. Validate:

Эмитент	Присвоенный кредитный рейтинг	Расчетный рейтинг	Ошибка
ОАО "АКЦИОНЕРНАЯ КОМПАНИЯ ПО ТРАНСПОРТУ НЕФТИ "ТРАНСНЕФТЬ"	BBB	BBB	-
ОАО "ГАЗПРОМ НЕФТЬ"	BBB	BBB	-
ОАО "НЕФТЯНАЯ КОМПАНИЯ "ЛУКОЙЛ"	BBB	BB	1
ОАО "РОССИЙСКИЕ ЖЕЛЕЗНЫЕ ДОРОГИ"	BBB	BBB	-
ОАО "ФЕДЕРАЛЬНАЯ СЕТЕВАЯ КОМПАНИЯ ЕДИНОЙ ЭНЕРГЕТИЧЕСКОЙ СИСТЕМЫ"	BBB	BBB	-
ОАО "ГАЗПРОМ"	BBB	BBB	-
ОАО "ГОРНО-МЕТАЛЛУРГИЧЕСКАЯ КОМПАНИЯ "НОРИЛЬСКИЙ НИКЕЛЬ"	BBB	BBB	-
ОАО "МОСКОВСКАЯ ОБЪЕДИНЕННАЯ ЭЛЕКТРОСЕТЕВАЯ КОМПАНИЯ"	BB	BB	-
ЗАО "ГРАЖДАНСКИЕ САМОЛЕТЫ СУХОГО"	BB	BB	-
ОАО "Московская объединенная энергетическая компания"	BB	BB	-
ОАО "ТАТТЕЛЕКОМ"	BB	B	1
ОАО "АКЦИОНЕРНАЯ ФИНАНСОВАЯ КОРПОРАЦИЯ "СИСТЕМА"	BB	BB	-
ОАО "МОБИЛЬНЫЕ ТЕЛЕСИСТЕМЫ"	BB	BB	-

Problems of simple algorithm

1. Lack of rated issuers (almost no CCC, no BBB bond issuers for regions, etc.)
2. Not powerful enough: average error 0.3 grades

Solutions:

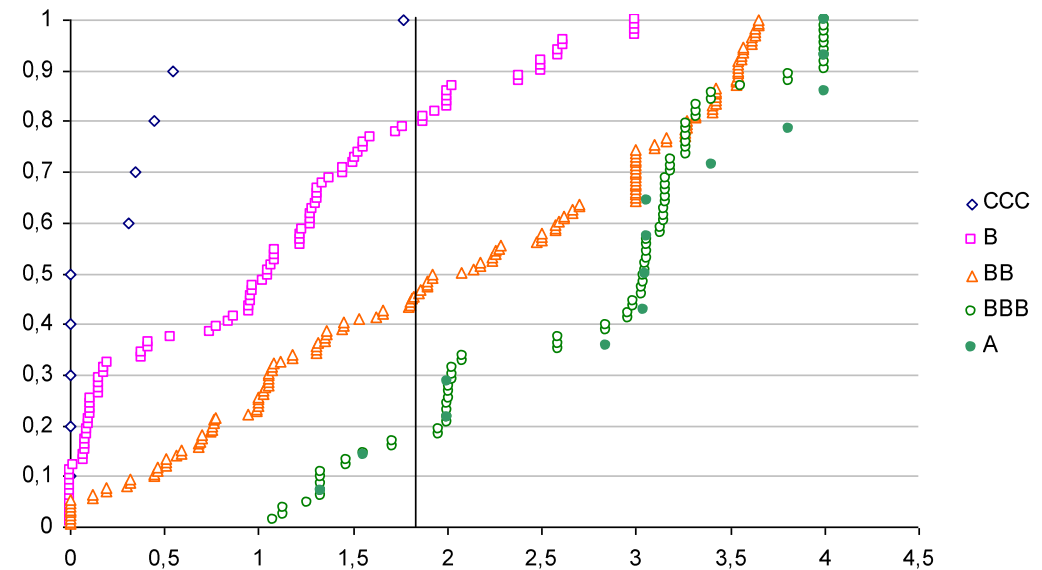
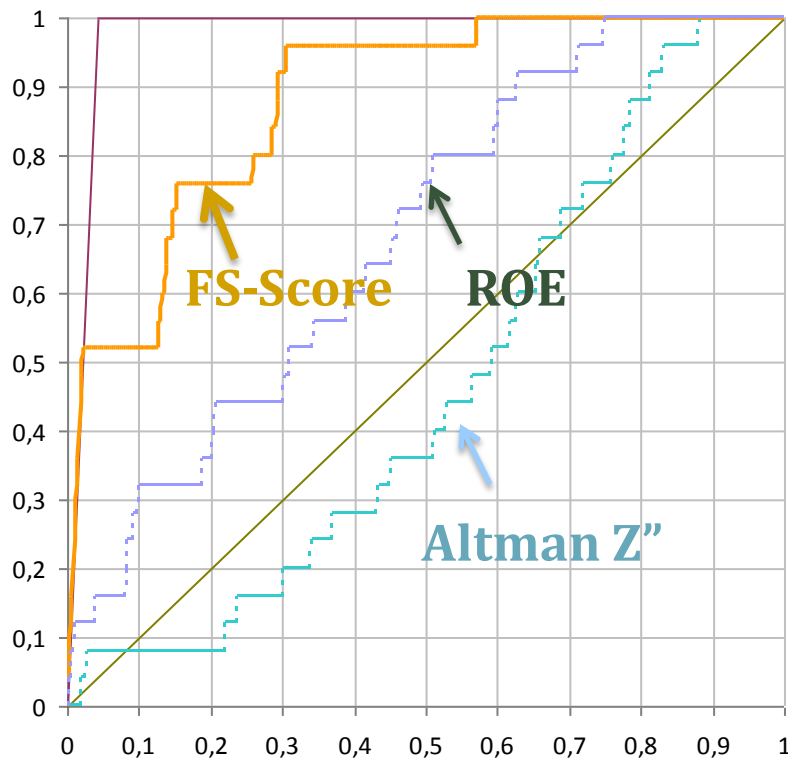
1. Use larger sample, incorporate defaults cases
2. Use more powerful classification methods: logit, trees, etc.
3. Search for predictors

For example: Simple fuzzy score model

S.Ivliev. Simple Fuzzy Score for Russian Public Companies Risk of Default.

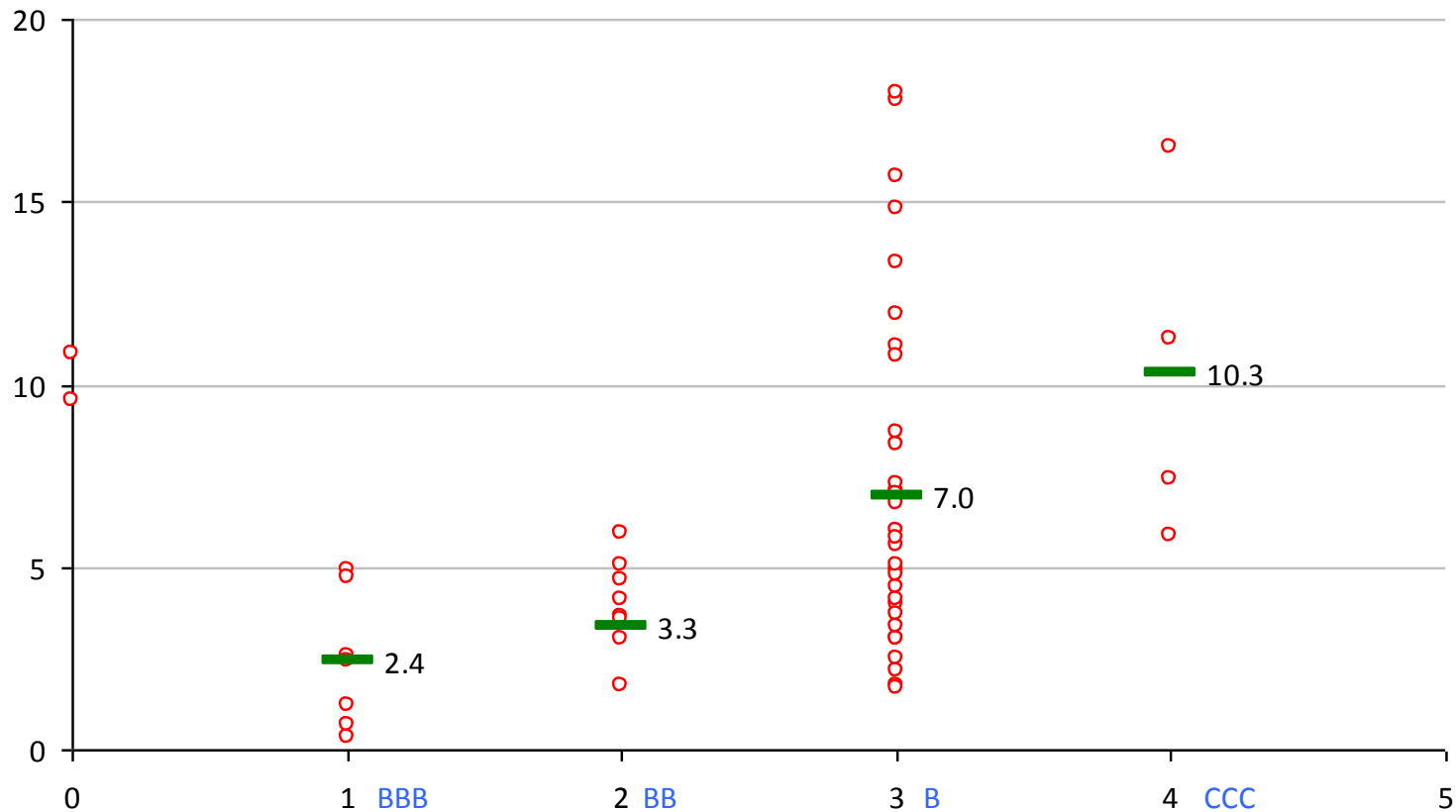
<http://arXiv.org/abs/1004.0685>

4 variables, In-sample accuracy ratio 72%



Sample: 126 companies, 25 defaults (2008-2009), 588 datapoints

Next problem – credit rating is not the only one...



Average spreads for Russian banks for 2008.

Need to add more factors:

$$\lambda(t) = \gamma R(t) + \beta^T F(t) + \varepsilon$$

where

λ - credit spread,

R - credit rating,

F - other factors (liquidity, issue features...)

Pricing Center Project (PCP)



Fair price of bonds daily calculation
4 price component open methodology
7 data sources
786 bonds
Free access
Launching at 2011

Thank you!

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permwinterschool.ru

